REMARKS

This is a Response to the Office Action mailed June 13, 2007, in which a three (3) month Shortened Statutory Period for Response has been set, due to expire September 13, 2007. No fee for additional claims is due by way of this Response. The Director is authorized to charge any additional fees due by way of this Response, or credit any overpayment, to our Deposit Account No. 19-1090. Claims 1-25 remain pending.

1. Rejections Under 35 U.S.C. § 112, Second Paragraph

Claims 1-25 were rejected under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite for failing to point out and distinctly claim the subject matter which the applicant regards as his invention, apparently because the claims allegedly use the phrase "such as" or the like. The Office Action then appears to allege that the references to the Vickers hardness range of 30 mgf/μm^2 to 50 mgf/μm^2 in claim 1 and 5, the range of 33 mgf/μm^2 to 50 mgf/μm^2 in claims 2 and 6, and the range of 30 mgf/μm^2 to 50 mgf/μm^2 in claims 3 and 7, render these claims indefinite. Applicants traverse the rejection under 35 U.S.C. § 112, second paragraph, for at least the following reasons.

a. Claims Do Not Have the Phrase "Such As"

The Office Action apparently alleges that "a broad range or limitation together with a narrow range of limitation that falls within the broad range or limitation (in the same claim) is considered indefinite, since the resulting claim does not clearly set forth the metes and bounds of the patent protection desired. See MPEP § 2173.05(c)." The Examiner directs the Applicants to *ex parte Wu* (10 U.S.P.Q.2d 2031), *ex parte Steigewald* (131 U.S.P.Q. 74) , and other cases where the phrase "such as" renders a claim indefinite. However, claims 1-21 ***do not*** recite the phrase "such as" or any other type of phrase which would render the claims indefinite. Accordingly, the rejection should be withdrawn if based upon an allegation that the claims recite the indefinite phrase "such as" or the like.

b. Independent Claim 1

Claim 1 recites "at least one light transmission film having Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2." Claim 1 permissibly recites a single range for the Vickers hardness. Claim 1 does not contain any terms or phrases that would render the claim itself indefinite. Accordingly, the rejection to claim 1 under 35 U.S.C. § 112, second paragraph, is improper and should be withdrawn.

c. Dependent Claims 4 and 8-25

Other than the rejection of claim 1 under 35 U.S.C. § 112, second paragraph, the Office Action provides no additional basis for rejecting claims 4 and 8-25 under 35 U.S.C. § 112, second paragraph. Since claim 1 is not indefinite and the corresponding rejection under 35 U.S.C. § 112, second paragraph, of claim 1 is improper, and since claims 4 and 8-25 contain no phrases which are alleged to be objectionable, the rejection of claims 4 and 8-25 should also be withdrawn.

d. Dependent Claim 5

Claim 5 recites "*a first light transmission film* which is located on the side of the recording layer and *has Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2* with respect to a load of 200 mgf and a second light transmission film located on the side of the light incidence plane through which a laser beam enters" (emphasis added). Here, claim 5 permissibly narrows the respective limitation of claim 1. More particularly, claim 5 recites a "first light transmission film" which has the Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2 with respect to a load of 200 mgf (as contrasted with the recited "at least one light transmission film" of claim 1). Claim 5 further recites "a second light transmission film" that does not have the recited Vickers hardness. In contrast, claim 1 recites that the "at least one light transmission film" has the Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2. Accordingly, claim 5 narrows the scope of claim 1 in a permissible manner. Thus, the rejection to claim 5 is improper and should be withdrawn.

e. Dependent Claim 2

Claim 2 recites "an optical recording medium *in accordance with Claim 1*, wherein the at least one light transmission film has Vickers hardness of 33 mgf/μm^2 to 50 mgf/μm^2" (emphasis added). Claim 2 recites that the "at least one light transmission film" of claim 1 has a more narrow range of Vickers hardness. More particularly, the Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2 recited in claim 1 is narrowed to a Vickers hardness of 33 mgf/μm^2 to 50 mgf/μm^2 in claim 2.

MPEP § 2173.05(c) indicates that "while a single claim that includes both a broad and a narrow range may be indefinite, it is not improper under 35 U.S.C. 112, second paragraph, to present a dependent claim that sets forth a narrower range for an element than the range set forth in the claims from which it depends." Here, claim 2 narrows the range of the Vickers hardness of claim 1 in a permissible manner. Thus, the rejection to claim 2 is improper and should be withdrawn.

f. Dependent Claim 3

Claim 3 recites "an optical recording medium *in accordance with Claim 2*, wherein the at least one light transmission film has Vickers hardness of 33 mgf/μm^2 to 42 mgf/μm^2" (emphasis added). Claim 3 recites that the "at least one light transmission film" of claim 2 has a more narrow range of Vickers hardness. More particularly, the Vickers hardness of 33 mgf/μm^2 to 50 mgf/μm^2 recited in claim 2 is narrowed to a Vickers hardness of 33 mgf/μm^2 to 42 mgf/μm^2 in claim 3.

MPEP § 2173.05(c) indicates that "while a single claim that includes both a broad and a narrow range may be indefinite, it is not improper under 35 U.S.C. 112, second paragraph, to present a dependent claim that sets forth a narrower range for an element than the range set forth in the claims from which it depends." Here, claim 3 narrows the range of the Vickers hardness of claim 2 in a permissible manner. Thus, the rejection to claim 3 is improper and should be withdrawn.

g. Dependent Claim 6

Claim 6 recites "an optical recording medium *in accordance with Claim 5*, wherein the first light transmission film has Vickers hardness of 33 mgf/μm^2 to 50 mgf/μm^2" (emphasis added). Claim 6 recites that the "first light transmission film" of claim 5 has a more narrow range of Vickers hardness. More particularly, the Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2 recited in claim 5 is narrowed to a Vickers hardness of 33 mgf/μm^2 to 50 mgf/μm^2 in claim 6.

MPEP § 2173.05(c) indicates that "while a single claim that includes both a broad and a narrow range may be indefinite, it is not improper under 35 U.S.C. 112, second paragraph, to present a dependent claim that sets forth a narrower range for an element than the range set forth in the claims from which it depends." Here, claim 6 narrows the range of the Vickers hardness of claim 5 in a permissible manner. Thus, the rejection to claim 6 is improper and should be withdrawn.

h. Dependent Claim 7

Claim 7 recites "an optical recording medium *in accordance with Claim 6*, wherein the first light transmission film has Vickers hardness of 33 mgf/μm^2 to 42 mgf/μm^2" (emphasis added). Claim 7 recites that the "first light transmission film" of claim 6 has a more narrow range of Vickers hardness. More particularly, the Vickers hardness of 33 mgf/μm^2 to 50 mgf/μm^2 recited in claim 6 is narrowed to a Vickers hardness of 33 mgf/μm^2 to 42 mgf/μm^2 in claim 7.

MPEP § 2173.05(c) indicates that "while a single claim that includes both a broad and a narrow range may be indefinite, it is not improper under 35 U.S.C. 112, second paragraph, to present a dependent claim that sets forth a narrower range for an element than the range set forth in the claims from which it depends." Here, claim 7 narrows the range of the Vickers hardness of claim 6 in a permissible manner. Thus, the rejection to claim 7 is improper and should be withdrawn.

2. Rejections Under 35 U.S.C. § 103(a)

In the Office Action, at paragraph 5, claims 1, 4, 5, 8, 9, 10, 12, and 13 stand rejected under 35 U.S.C. § 103(a) as allegedly unpatentable over *Aratani et al.* (U.S. Patent 6,063,468), hereinafter *Aratani*, in view of *Zhou et al.* (U.S. Publication No. 2004/0157159), hereinafter *Zhou*. It is well-established at law that, for a proper rejection of a claim under 35 U.S.C. § 103 as being obvious based upon a combination of references, the cited combination of references must disclose, teach, or suggest, either implicitly or explicitly, all elements and/or features of the claim at issue. See, *e.g.*, *In Re Dow Chemical*, 5 U.S.P.Q.2d 1529, 1531 (Fed. Cir. 1988), and *In re Keller*, 208 U.S.P.Q. 871, 881 (C.C.P.A. 1981).

a. Claims 1, 4, 5, 8, 9, 10, 12, and 13 Rejected Under *Aratani* in view of *Zhou*

As noted above, claims 1, 4, 5, 8, 9, 10, 12, and 13 stand rejected under the proposed combination of *Aratani* in view of *Zhou*. However, *Aratani* in view of *Zhou* does not disclose, teach, or suggest "at least one light transmission film having Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2 with respect to a load of 200 mgf" as recited in claim 1.

As noted in the Office Action at page 4, *Aratani* does not disclose, teach, or suggest the feature of "at least one light transmission film having Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2 with respect to a load of 200 mgf" recited in claim 1.

Next, the text of the Office Action rejection itself asserts that "Uchiyama et al. make obvious of such range." All further references to the rejection of claims 1, 4, 5, 8, 9, 10, 12, and 13 refer to *Uchiyama*. The Office Action does not reject any of the claims using *Zhou*.

Since *Zhou* fails to disclose, teach or suggest the above recited feature of claim 1, and since the Office Action is not using *Zhou* to reject the claims, the proposed combination of *Aratani* in view of *Zhou* does not establish a *prima facie* case of an obviousness rejection as stated in the Office Action. Therefore, the rejection as stated should be withdrawn.

b. Independent Claim 1 Rejected Under *Aratani* in view of *Uchiyama*

To advance prosecution of the instant application, Applicants consider the combination of *Aratani* in view of *Uchiyama et al.* (U.S. Publication No. 2003/0043730),

hereinafter *Uchiyama*. *Uchiyama* is identified in the Notice of References Cited. However, if the Applicants' assumption above that *Uchiyama* is the intended art used to establish the basis of rejection of claims 1, 4, 5, 8, 9, 10, 12, and 13 is not correct, Applicants respectfully request clarification in the next Office Action. That is, a new rejection should be provided in the next Office Action which clearly identifies the references used to establish the basis of rejection.

Further, if art other than *Uchiyama* (U.S. Publication No. 2003/0043730) is used as the prior art to establish the basis of the rejection of claims 1, 4, 5, 8, 9, 10, 12, and 13, then such prior art would constitute *new* prior art. Accordingly, the next Office Action should be non-final.

With respect to *Aratani* in view of *Uchiyama*, Applicants respectfully traverse the rejection for at least the following reasons. Claim 1 is allowable for at least the reason that the proposed combination of *Aratani* in view of *Uchiyama* does not disclose, teach, or suggest at least the feature of "at least one light transmission film having *Vickers hardness* of 30 mgf/μm^2 to 50 mgf/μm^2 *with respect to a load of 200 mgf*" as recited in claim 1 (emphasis added).

As noted in the Office Action at page 4, *Aratani* does not disclose, teach, or suggest the above-recited feature of claim 1. Next, the Office Action asserts that "Uchiyama et al. make obvious of such range." However, *Uchiyama* only discloses that "satisfying an optical film hardness of 16 kg/mm^2 or greater can give an optical film with particularly excellent mar-proof properties. The hardness is preferably 18 kg/mm^2 or greater, and more preferably 20 kg/mm^2 or greater" (paragraph [0124]). *Uchiyama* does not go so far as to disclose, teach or suggest a Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2 with respect to a load of 200 mgf for at least the following reasons.

First, *Uchiyama* only discloses a film hardness of "20 kg/mm^2 or greater." However, *Uchiyama* does not disclose that the hardness is based upon the <u>*Vickers hardness test*</u>. Attached for the convenience of the Examiner is a copy of the Wikipedia free encyclopedia web page for "Hardness" which demonstrates that with respect to indentation hardness, many different hardness tests are available to measure hardness. Examples of hardness tests include:

Brinell hardness test,

Knoop hardness test,

Meyer hardness test,

Rockwell hardness test,

Shore durometer hardness test,

Vickers hardness test, and

Barcol hardness test.

One skilled in the art appreciates the nature of the various types of hardness tests listed above. An exemplary Vickers hardness test employs a squares-based pyramid diamond having an angle of 136° between opposite faces, and 22° between the indenter face and surface (see Wikipedia free encyclopedia web page for "Vickers hardness test"). Other types of hardness tests use other devices to measure material hardness.

Here, one skilled in the art after considering *Uchiyama* would, at most, understand only that "satisfying an optical film hardness of 16 kg/mm^2 or greater can give an optical film with particularly excellent mar-proof properties. The hardness is preferably 18 kg/mm^2 or greater, and more preferably 20 kg/mm^2 or greater" (paragraph [0124]). One skilled in the art *would not* appreciate precisely which hardness test was used to derive the *Uchiyama* hardness of "preferably 20 kg/mm^2 or greater."

To infer that the disclosed *Uchiyama* hardness of "preferably 20 kg/mm^2 or greater" is based upon a Vickers hardness test, and not from one of the many other available hardness tests, requires an assumption on the part of the Office Action that is not supported in the *Uchiyama* disclosure.

Accordingly, under the proposed combination of *Aratani* in view of *Uchiyama*, the use of the recited Vickers hardness test is not disclosed. Accordingly, the proposed combination of *Aratani* in view of *Uchiyama* does not establish a *prima facie* case of an obviousness rejection. Accordingly, claim 1 is not obvious under the proposed combination of *Aratani* in view of *Uchiyama* and the rejection should be withdrawn.

To establish a proper basis of rejection under *Uchiyama*, the Office Action must *infer* that the disclosed *Uchiyama* hardness of "preferably 20 kg/mm^2 or greater" is based upon a Vickers hardness test. That is, because there are so many alternative hardness tests, none of which are disclosed in *Uchiyama*, the Office Action must assume facts that are not of record to

infer that the disclosed *Uchiyama* hardness of "preferably 20 kg/mm^2 or greater" is based upon a Vickers hardness test.

To establish an inference that the *Uchiyama* hardness of "preferably 20 kg/mm^2 or greater" is based upon a Vickers hardness test, it appears that the Office Action may be using hindsight to go well beyond the actual disclosure in *Uchiyama* to conclude that the disclosed *Uchiyama* hardness of "preferably 20 kg/mm^2 or greater" is based upon a Vickers hardness test. MPEP §2142 requires that "to reach a proper determination under 35 U.S.C. 103, the examiner must step backward in time and into the shoes worn by the hypothetical 'person of ordinary skill in the art' when the invention was unknown and just before it was made. In view of all factual information, the examiner must then make a determination whether the claimed invention 'as a whole' would have been obvious at that time to that person. Knowledge of applicant's disclosure must be put aside in reaching this determination, yet kept in mind in order to determine the 'differences,' conduct the search and evaluate the 'subject matter as a whole' of the invention. The tendency to resort to 'hindsight' based upon applicant's disclosure is often difficult to avoid due to the very nature of the examination process. However, impermissible hindsight must be avoided and the legal conclusion must be reached on the basis of the facts gleaned from the prior art."

Here, the Applicants' specification clearly discloses the use of the Vickers hardness test. *Uchiyama* does not disclose a Vickers hardness test. To arrive at the conclusion that the proposed combination of *Aratani* in view of *Uchiyama* discloses a Vickers hardness test, the Applicants' disclosure must be used to establish a basis for rejection. Since this is an improper use of hindsight, a *prima facie* case establishing an obviousness rejection has not been properly made in the Office Action. Accordingly, claim 1 is not obvious under the proposed combination of *Aratani* in view of *Uchiyama* and the rejection should be withdrawn.

Alternatively, even if the Office Action assumes facts that are not of record to infer that the disclosed *Uchiyama* hardness of "preferably 20 kg/mm^2 or greater" is based upon a Vickers hardness test, such an assumption would have to be asserted under common knowledge possessed by one skilled in the art. MPEP § 2144.03 indicates that "an obviousness rejection may be based upon common knowledge in the art." However, MPEP § 2144.03 further requires that "if

the applicant traverses such an assertion the examiner should cite a reference in support of his or her position." Since the Applicants have traversed the allegation used to reject claim 1 in the Office Action, and provided sound reasoning in support of the traverse (that the disclosed *Uchiyama* hardness of "preferably 20 kg/mm^2 or greater" is based upon a Vickers hardness test, and is not based on any of the other known hardness tests), Applicants respectfully request that the Examiner provide such a citation as required under MPEP § 2144.03.

Second, *Uchiyama* does not go so far as to disclose that the film hardness of "20 kg/mm^2 or greater" is a Vickers hardness *with respect to a load of 200 mgf*. The measurement of hardness under a Vickers hardness test is based upon a known applied load exerted on the diamond indenter (see Wikipedia free encyclopedia web page for "Vickers hardness test"). *Uchiyama* fails to disclose the above-recited feature of claim 1. Therefore, even if *Aratani* is modified by *Uchiyama*, and is further modified by assuming facts that are not of record to infer that the disclosed *Uchiyama* hardness is based upon a Vickers hardness test, there is simply no disclosure whatsoever of "at least one light transmission film having Vickers hardness of 30 $mgf/\mu m^2$ to 50 $mgf/\mu m^2$ *with respect to a load of 200 mgf*" as recited in claim 1 (emphasis added).

Accordingly, the proposed combination of *Aratani* in view of *Uchiyama* does not disclose at least the above-recited limitation of claim 1 (with respect to a load of 200 mgf). Therefore, a *prima facie* case establishing an obviousness rejection by *Aratani* in view of *Uchiyama* has not been made. Thus, claim 1 is not obvious under the proposed combination of *Aratani* in view of *Uchiyama*, and the rejection should be withdrawn.

Third, the proposed combination of *Aratani* in view of *Uchiyama* does not disclose "a *recording layer* located between the support substrate and the light transmission layer and containing an *organic dye as a primary component*" as recited in claim 1 (emphasis added). As noted by the Office Action at page 4, "the combined teaching of *Aratani* and *Uchiyama* fails to teach the recording layer containing an organic dye as a primary component as claimed. However, Official Notice is taken that using an organic dye as a primary component in a recording layer is notoriously well known in the art for the benefit of writing data once to the recording." However, Applicants traverse the use of the alleged common knowledge (using an

organic dye as a primary component in a recording layer) in combination with *Aratani* and *Uchiyama* for at least the following reason.

The combination of *Aratani* and *Uchiyama*, in further combination with the alleged common knowledge pertaining to organic dye recording layers, is improper under the new *KSR* guidelines (*KSR Int'l Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 82 U.S.P.Q.2d 1385 (2007)). *KSR* indicates that when determining whether a *prima facie* case of an obviousness rejection has been properly established, "a court must ask whether the improvement is more than the predictable use of prior art elements according to their established functions."

Here, neither *Aratani* or *Uchiyama* contemplate using an organic dye as a primary component in a recording layer. Accordingly, the difficulties encountered in optical recording media using an organic dye as a primary component in a recording layer are not at all contemplated by either *Aratani* or *Uchiyama*. The Applicants' Specification describes the difficulty when using an organic dye as a primary component in a recording layer:

> When data are recorded in the write-once type optical recording medium, it is normal not only for an organic dye contained in the recording layer to be chemically changed but also for the support substrate and layers close to the recording layer to be physically deformed. However, a write-once type optical recording medium having a recording layer containing an organic dye includes a reflective layer composed of metal having high thermal conductivity located on the side of the recording layer opposite-from the side of the light incidence plane so as to be adjacent to the recording layer. Layers located on the same side of the recording layer as the incidence plane and the support substrate are therefore liable to be physically deformed. Although this increases modulation of a reproduced signal and the recording sensitivity of the optical recording medium, it also creates a risk of a reproduced signal being degraded and adjacent tracks being affected when these layers are physically deformed too much. (Page 3, lines 11-25.)

In solution to the above-described difficulty in using an organic dye as a primary component in a recording layer, the Applicants have found that:

> In order to decrease jitter of a signal reproduced from the optical recording medium, the at least one light transmission film preferably has Vickers hardness equal to or higher than 30 mgf/.mu.m^2 and more preferably has Vickers hardness equal to or higher than 33 mgf/μm^2.

> To the contrary, in a study done by the inventors of the present invention, it was found that as shown in FIG. 1, as the hardness of the at least one light transmission film decreased, the optimum recording power of a laser beam for recording data in the optical recording medium, namely the recording power of the laser beam at which jitter of a signal reproduced from the optical recording medium became lowest, decreased, and therefore, the recording sensitivity of the optical recording medium improved as the hardness of the at least one light transmission film decreased. (Page 8, lines 9-21.)

Based upon the ***unexpected** results* discovered by the Applicants,

> It was found that in the case where the at least one light transmission film had Vickers hardness of 30 mgf/.mu.m.sup.2 to 50 mgf/.mu.m.sup.2, it was possible to improve the recording characteristics of the optical recording medium and prevent the mechanical strength of the optical recording medium from being lowered and it was possible to simultaneously improve the characteristics of a signal reproduced from the optical recording medium. (Page 8, lines 2-8.)

Summarizing, because of the difficulties in using an organic dye as a primary component in a recording layer (physical deformation and jitter), the Applicants' tests demonstrating unexpected results led to the discovery of an improved range of hardness for the light transmission layer.

One skilled in the art familiar with using an organic dye as a primary component in a recording layer, after consideration of *Aratani* and *Uchiyama*, would not have realized the improvement discovered by the Applicants in using "at least one light transmission film having Vickers hardness of 30 mgf/μm^2 to 50 mgf/μm^2 with respect to a load of 200 mgf" in a recording medium where an organic dye is a primary component in a recording layer. Accordingly, under the guidelines of *KSR*, it is not obvious to combine the disclosures of *Aratani* and *Uchiyama* with a media using an organic dye as a primary component in a recording layer as alleged by the Office Action.

c. Dependent Claims 4, 5, 8, 9, 10, 12, and 13

Because independent claim 1 is allowable over the cited art of record, dependent claims 4, 5, 8, 9, 10, 12, and 13 (which depend from independent claim 1) are allowable as a matter

of law for at least the reason that the dependent claims 4, 5, 8, 9, 10, 12, and 13 contain all features/elements of independent claim 1. See, *e.g.*, *In re Fine*, 837 F.2d 1071 (Fed. Cir. 1988). Accordingly, the rejection to these claims should be withdrawn.

3. Rejections Under 35 U.S.C. § 103(a)

In the Office Action, at paragraph 6, claims 11, and 14-19 stand rejected under 35 U.S.C. § 103(a) as allegedly unpatentable over *Aratani* in view of *Uchiyama*, and further in view of *Zhou*. At paragraph 7, claims 20-25 stand rejected under 35 U.S.C. § 103(a) as allegedly unpatentable over *Aratani*, in view of *Uchiyama*, and further in view of *Saito* (U.S. Publication No. 2003/0138728).

Because independent claim 1 is allowable over the cited art of record, dependent claims 11 and 14-25 (which depend from independent claim 1) are allowable as a matter of law for at least the reason that the dependent claims 11 and 14-25 contain all features/elements of independent claim 1. Accordingly, the rejection to these claims should be withdrawn.

4. Conclusion

In light of the above amendments and remarks, Applicants respectfully submit that all objections and/or rejections have been traversed, rendered moot, and/or accommodated, and that all pending claims 1-25 are allowable. Applicants, therefore, respectfully request that the Examiner reconsider this application and timely allow all pending claims. The Examiner is encouraged to contact Mr. Armentrout by telephone to discuss the above and any other distinctions between the claims and the applied references, if desired.

If the Examiner notes any informalities in the claims, he is further encouraged to contact Mr. Armentrout by telephone to expediently correct such informalities.

Respectfully submitted,

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Hardness

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From Wikipedia, the free encyclopedia
(Redirected from Hardness (materials science))

Hardness refers to various properties of matter in the solid phase that give it high resistance to various kinds of shape change when force is applied. **Hard matter** is contrasted with soft matter.

Macroscopic hardness is generally characterized by strong intermolecular bonds. However, the behavior of solid materials under force is complex, resulting in several different scientific definitions of what might be called "hardness" in everyday usage.

In materials science, there are three principal operational definitions of hardness:

- **Scratch hardness** - Resistance to fracture or plastic (permanent) deformation due to friction from a sharp object
- Indentation hardness - Resistance to plastic (permanent) deformation due to impact from a sharp object
- **Rebound hardness** - Height of the bounce of an object dropped on the material, related to elasticity.

In physics, hardness encompasses:

- Elasticity, plasticity, viscosity, and viscoelasticity
- Strength and strain
- Brittleness/ductility and toughness

Contents

Materials science

In materials science, **hardness** is the characteristic of a solid material expressing its resistance to permanent deformation. Hardness can be measured on the Mohs scale or various other scales. Some of the other scales used for indentation hardness in engineering - Rockwell, Vickers, and Brinell - can be compared using practical conversion tables.

Scratch hardness

In mineralogy, *hardness* commonly refers to a material's ability to penetrate softer materials. An object made of a *hard* material will scratch an object made of a *softer* material. Scratch hardness is usually measured on the Mohs scale of mineral hardness. One tool to make this measurement is the sclerometer.

Pure diamond is the hardest known natural mineral substance and will scratch any other natural material. Diamond is therefore used to cut other diamonds; in particular, higher-grade diamonds are used to cut lower-grade diamonds.

The hardest substance known today is aggregated diamond nanorods, with a hardness 1.11 times diamond. Estimates from proposed molecular structure indicate the hardness of beta carbon nitride should also be greater than diamond (but less than ultrahard fullerite). This material has not yet been successfully synthesized.

Indentation hardness

Primarily used in engineering and metallurgy, indentation hardness seeks to characterise a material's hardness; i.e. its resistance to permanent, and in particular plastic, deformation. It is usually measured by loading an indenter of specified geometry onto the material and measuring the dimensions of the resulting indentation.


A Vickers hardness tester

There are several alternative definitions of indentation hardness, the most common of which are

- Brinell hardness test (HB);
- Janka Wood Hardness Rating;
- Knoop hardness test (HK) or microhardness test, for measurement over small areas;
- Meyer hardness test;
- Rockwell hardness test (HR), principally used in the USA;
- Shore durometer hardness, used for polymers;
- Vickers hardness test (HV), has one of the widest scales;
- Barcol hardness test, for composite materials, scale from 0 to 100.

There is, in general, no simple relationship between the results of different hardness tests. Though there are practical conversion tables for hard steels, for example, some materials show qualitatively different behaviours under the various measurement methods.

Hardness increases with decreasing particle size. This is known as the Hall-Petch effect. However, below a critical grain-size, hardness decreases with decreasing grain size. This is known as the inverse Hall-Petch effect.

For measuring hardness of nanograined materials, nanoindentation is used.

In the December 4, 2005 issue of The Jerusalem Post, Professors Eli Altus, Harold Basch and Shmaryahu Hoz, with doctoral student Lior Itzhaki reported (http://www.jpost.com/servlet/Satellite?cid=1132475677365&pagename=JPost%2FJPArticle%2FShowFull) the discovery of a polyyne that is

40 times harder than diamond. It is a "superhard" molecular rod, comprised of acetylene units.

It is important to note that hardness of a material to deformation is dependent to its microdurability or small-scale shear modulus in any direction, not to any rigidity or stiffness properties such as the bulk modulus or Young's modulus. Scientists and journalists often confuse stiffness for hardness[1][2], and spuriously report materials that are not actually harder than diamond because the anisotropy of their solid cells compromise hardness in other dimensions, resulting in a material prone to spalling and flaking in squamose or acicular habits in that dimension. e.g., Osmium is stiffer than diamond but is as hard as quartz. In other words, a claimed hard material should have similar hardness characteristics at any location on its surface.

Rebound hardness

Also known as *dynamic hardness*, rebound hardness measures the height of the "bounce" of a diamond-tipped hammer dropped from a fixed height onto a material. The device used to take this measurement is known as a scleroscope. [3]

One scale that measures rebound hardness is the Bennett Hardness Scale.

Physics

In solid mechanics, solids generally have three responses to force, depending on the amount of force and the type of material:

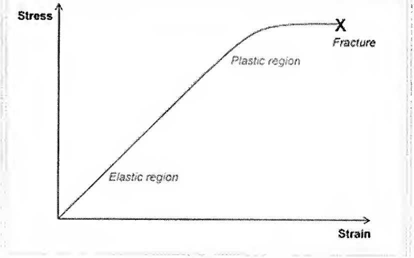

Diagram of a Stress-strain curve, showing the relationship between stress (force applied per unit area) and strain or deformation of a ductile metal.

- They exhibit elasticity - the ability to temporarily change shape, but return to the original shape when the pressure is removed. "Hardness" in the elastic range - a small temporary change in shape for a given force - is known as stiffness in the case of a given object, or a high elastic modulus in the case of a material.
- They exhibit plasticity - the ability to permanently change shape in response to the force, but remain in one piece. The yield strength is the point at which elastic deformation gives way to plastic deformation. Deformation in the plastic range is non-linear, and is described by the stress-strain curve. This response produces the observed properties of scratch and indentation hardness, as described and measured in materials science. Some materials exhibit both elasticity and viscosity when undergoing plastic deformation; this is called viscoelasticity.
- They fracture - split into two or more pieces. The "ultimate strength" or toughness of an object is the point at which fracture occurs.

Strength is a measure of the extent of a material's elastic range, or elastic and plastic ranges together. This is quantified as compressive strength, shear strength, tensile strength depending on the direction of the forces involved. Ultimate strength is measure of the maximum strain a material can withstand.

Brittleness, in technical usage, is the tendency of a material to fracture with very little or no detectable deformation beforehand. Thus in technical terms, a material can be both brittle and strong. In everyday usage "brittleness" usually refers to the tendency to fracture under a small amount of force, which exhibits both brittleness and a lack of strength (in the technical sense). For brittle materials, yield strength and ultimate strength are the same, because they do not experience detectable plastic deformation. The opposite of brittleness is ductility.

The toughness of a material is the maximum amount of energy it can absorb before fracturing, which is different than the amount of force that can be applied. Toughness tends to be small for brittle materials, because it is elastic and plastic deformations that allow materials to absorb large amounts of energy.

Materials whose properties are different in different directions (because of an asymmetrical crystal structure) are referred to as anisotropic.

Examples of hard matter

- Ceramics
- Composites
- Metals
- Semiconductors
- Penises
- My Manly Loving For your sweet asshole

External links

- An introduction to materials hardness (http://www.calce.umd.edu/general/Facilities/Hardness_ad_.htm)

References

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2. ^ "Hard as a Diamond?" (http://focus.aps.org/story/v4/st31): "..bulk modulus would be surpassed only by diamond; and if combined with some impurity atoms to fill in the voids, it might be even harder than diamond." (1999).
3. ^ [1] (http://www.articlestree.com/science/a-guide-to-rebound-hardness-and-scleroscope-test-tx301428.html)

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Vickers hardness test

From Wikipedia, the free encyclopedia

The **Vickers hardness test** was developed in the early 1920s as an alternative method to measure the hardness of materials. The Vickers test often easier to use than other hardness tests since the required calculations are independent on the size of the indenter, and the indenter can be used for all materials irrespective of hardness. The

A Vickers hardness tester

basic principle, as with all common measures of hardness, is to observe the questioned materials' ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as the **Vickers Pyramid Number (HV)**. The hardness number can be converted into units of Pa, but should not be confused with a pressure, which also has units of Pa. The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force, and is therefore not a pressure.

The hardness number is not really a true property of the material and is an empirical value that should be seen in conjunction with the experimental methods and hardness scale used. When doing the hardness tests the distance between indentations must be more than 2.5 indentation diameters apart to avoid interaction between the work-hardened regions.

The yield strength of the material can be approximated as

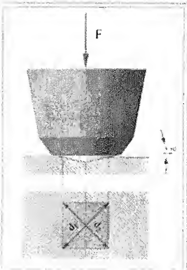
$$H_V = c\sigma \approx 3\sigma.$$

where c is a constant determined by geometrical factors usually ranging between 2 and 4.

Contents

Implementation

The Vickers hardness test uses a diamond, with the shape of square-based pyramid with an angle of 136° between opposite faces as an indenter (22° between the indenter face and surface). It is based on the principle that impressions made by this indenter are geometrically similar regardless of load. Accordingly, loads of various magnitudes are applied to a flat surface, depending on the hardness of the material to be measured. The Vickers Pyramid Number (HV) is then determined by the ratio **F/A** where **F** is the force applied to the diamond and **A** is the surface area of the resulting indentation. **A** can be determined by the formula



Vicker's test scheme

$$A = \frac{d^2}{2\ sin(136°/2)},$$

which can be approximated by evaluating the sine term to give

$$A \approx \frac{d^2}{1.854},$$

where d is the average length of the diagonal left by the indenter. Hence,

$$H_V = \frac{F}{A} \approx \frac{1.854F}{d^2}.$$

The corresponding units of HV are then kilogram-force per square millimetre (kgf/mm²). To convert a Vickers hardness number in SI units (MPa or GPa) one needs to convert the force applied from kgf to newtons and the area from mm^2 to m^2 to give results in pascals (1 kgf/mm² = 9.80665×10^6 Pa).

A practical method to convert HV to SI units:

To convert HV to MPa multiply by 9.807 *To convert HV to GPa multiply by 0.009807*

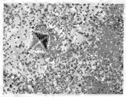
Vickers hardness numbers are reported as **xxxHVyy**, e.g. **440HV30**, where:

- **440** is the hardness number,
- **HV** gives the hardness scale (Vickers),
- **30** indicates the load used in kgf.

Examples

Some HV values[1]

- Stainless Steels 140-180HV30 (316L & 347L stainless respectively)
- Carbon Steel 55-120HV5 (Note: load is different to that of stainless)
- Iron 30-80HV5



Case Hardened Steel - Rapid Quench - Vickers Hardness Test

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- Vickers hardness test (http://www.gordonengland.co.uk/hardness/vickers.htm) on Gordon England site.

See also

- Hardness (materials science)
- Brinell hardness test
- Rockwell scale
- Knoop hardness test
- Hardness comparison

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